

ELECTRIC TOOTHBRUSHES

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Cross Reference to Related Application

This application claims the benefit of U.S. Provisional Application No. 60/464,787, filed April 23, 2003, the substance of which is incorporated herein by reference.

Field of the Invention

10 The present invention relates to the field of toothbrushes, and more particularly, the invention relates to the field of electrically powered toothbrushes.

Background of the Invention

15 Most known electric toothbrushes utilize a single bristle carrier that is powered or otherwise driven by an electric motor incorporated in the toothbrush. The bristle carriers in these toothbrushes generally undergo rotary motion. Although satisfactory in certain respects, a need still exists for an improved powered toothbrush design.

20 Numerous attempts have been made to improve the design, efficiency, cleaning efficacy, simplicity, and/or commercial viability of electric toothbrushes. One approach has been the provision of multiple powered bristle carriers. Most artisans have grouped multiple sets of bristles along an end of a brush and incorporated a drive mechanism for simultaneously rotating each of the bristle sets, together. Exemplary designs include those disclosed in U.S. Patents 3,242,516; 4,156,620; 4,845,795; 5,088,145; 5,020,179; 4,827,550; and 4,545,087.

25 A related strategy is to group sets of bristles on multiple rotating bristle carriers, as disclosed in U.S. Patents 2,140,307 and 5,170,525. Rather than rotating each individual bristle set about its center, i.e. the approach adopted in the previously noted patents, the designs described in the '307 and '525 patents rotate multiple groups of bristle sets about the center of a bristle carrier. Specifically, multiple groups of bristle sets are disposed on a circular bristle carrier
30 and that bristle carrier, typically one of several, is rotated about its own axis.

U.S. Patent 5,070,567 describes a design combining the two previously noted strategies. A rotating bristle carrier is provided along with multiple individually rotatable bristle

sets. Although this design likely provides many of the advantages associated with each of its predecessors, the cleaning efficacy of spinning bristle sets, alone, is somewhat limited.

Yet another design is disclosed in U.S. Patent No. 5,617,603. The '603 patent describes an assembly of "staggered swing" brushes. Apparently, the two bristle carriers move
5 along a complex path within the plane of the toothbrush.

Although dual bristle carriers that undergo various combinations of movement have been disclosed in the prior art, there remains a need to provide an electric toothbrush with a plurality of bristle carriers in which at least one carrier undergoes a reciprocating or pivotal type of motion. Additionally, there is a need to provide an electric toothbrush with multiple bristle
10 carriers in which at least one of the carriers reciprocates while another component of the brush undergoes a particular type of motion that assists in the brushing operations.

Summary of the Invention

15 An electric toothbrush is provided. The electric toothbrush has an elongated body including a handle, a head, and a neck extending between the handle and the head. A plurality of bristle carriers are disposed on the head and each of the bristle carriers include a collection of bristle tufts. An electric motor is operatively connected to a shaft, both of which are disposed in the body of the toothbrush. Upon operation of the electric motor, the shaft moves in a
20 reciprocating motion. The shaft is operatively connected to at least one of the bristle carriers to move that carrier and associated carriers.

Brief Description of the Drawings

25 The present invention may take form in various components and arrangements of components, and in various techniques, methods, or procedures and arrangements of steps. The referenced drawings are only for purposes of illustrating preferred embodiments, they are not necessarily to scale, and are not to be construed as limiting the present invention.

It is believed that the present invention will be better understood from the
30 following description taken in conjunction with the accompanying drawings in which:

Fig. 1 is a perspective view of a preferred embodiment toothbrush in accordance with the present invention illustrating various planes and their orientation with respect to the toothbrush.

Fig. 2 is a perspective view of another preferred embodiment toothbrush in
35 accordance with the present invention.

Fig. 3 is a perspective view of another preferred embodiment toothbrush in accordance with the present invention.

Fig. 4 is a perspective view of another preferred embodiment toothbrush in accordance with the present invention.

5 Fig. 5 is a perspective view of the front and rear of a brush head of another preferred embodiment toothbrush in accordance with the present invention.

Fig. 6 is a detailed view of several preferred massaging elements utilized by the preferred embodiment toothbrush depicted in Fig. 5.

10 Fig. 7 is a detailed cross sectional view of the brush head of the preferred embodiment toothbrush shown in Fig. 5.

Fig. 8 is a detailed view of the front and rear of a brush head of another preferred embodiment toothbrush in accordance with the present invention.

Fig. 9 is a detailed view of several preferred massaging elements utilized by the preferred embodiment toothbrush depicted in Fig. 8.

15 Fig. 10 is a detailed cross sectional view of the brush head of the preferred embodiment toothbrush shown in Fig. 8.

Detailed Description of the Preferred Embodiments

Before describing the various preferred embodiments, it is instructive to define the various types of motions that the movable bristles of the various toothbrushes may undergo. As
20 used herein, the term "angular motion" refers to any angular displacement. "Linear motion" is movement along a straight or substantially straight, line or direction. "Curvilinear motion" is movement that is neither completely linear nor completely angular but is a combination of the two (e.g., curvilinear). These motions can be constant or periodic. Constant motion refers to motion
25 that does not change direction or path (i.e., is unidirectional). Periodic motion refers to motion that reverses direction or path. Constant angular motion is referred to as rotary motion, although features herein may be described as "rotatably mounted" which is intended to merely mean that angular motion, whether periodic or constant, is possible. Periodic angular motion is referred to as oscillating motion. Curvilinear motions can also be either constant (i.e., unidirectional) or
30 periodic (i.e., reverses direction). Periodic linear motion is referred to as "reciprocation". "Orbital motion" is a type of angular motion about an axis that is distinct from and is some distance apart from the center of the moving component, e.g. a shaft. This distance is referred to herein as the extent of offset of the orbital motion. Orbital motion may be either constant angular motion or periodic angular motion.

The above-described motions can occur along one or more axes of a bristle carrier, a toothbrush, a toothbrush head, etc. Accordingly, motion is described herein as being either one, two, or three dimensional motion depending upon the number of axial coordinates required to describe the position of a bristle carrier during its movement. The axes, **X**, **Y**, and **Z**, are shown in Fig. 1. One dimensional motion is motion that can be described by a single coordinate (e.g., **X**, **Y**, or **Z** coordinates). Typically, only linear motion can be one dimensional. For example, periodic linear motion substantially along only the **Y** axis is one dimensional motion (referred to herein as a “pulsing motion” or an “up and down motion”). Two dimensional motion is movement by a bristle carrier that requires two coordinates (e.g., **X** and **Y** coordinates) to describe the path of travel of the bristle carrier. Angular motion that occurs in a single plane is two dimensional motion since a point on a bristle carrier would need two coordinates to describe the path of travel. Three dimensional motion is movement by a bristle carrier that requires three coordinates (e.g., **X**, **Y**, and **Z** coordinates) to describe the path of travel of the bristle carrier. An example of three dimensional motion is movement by a bristle carrier in the path of a helix.

Since most of the bristle carrier motions described herein can be modified by adjusting various structural features, the description of a motion herein shall be automatically understood to accommodate these variations. For example, a motion that is described as oscillating about an axis can also include components of other motions (e.g., a reciprocating linear motion), especially where it is noted that modifications can be made to provide this second component of motion. Motions that are intended to exclude such modifications shall be described herein with the modifier “primarily” (e.g., “primarily oscillating” or “primarily reciprocating”) and are intended to exclude significant other types motion, but not other motions that might be incidental from manufacturing tolerances or variabilities or where it is difficult to completely eliminate another type of motion completely from the bristle carrier, as is sometimes the case. All motions described herein may be restricted to primarily the motion described if desired.

Fig. 1 is a perspective view of a preferred embodiment toothbrush 2 in accordance with the present invention. The toothbrush 2 comprises an elongated body 10 having a handle 30, a head 50, and a neck 40 extending between the handle 30 and the head 50. A switch 20 is provided or made accessible along the outer region of the body 10. As will be appreciated, the switch 20 actuates an electrical motor contained within the body 10 of toothbrush 2. The motor (not shown) and a drive mechanism as described herein (not shown) drive one or more bristle carriers disposed near a distal end of the toothbrush. Specifically, the toothbrush 2 further includes a first bristle carrier 60 located adjacent a distal-most first end 52 and a second bristle carrier 70. As described in greater detail herein, upon activation of the drive mechanism, the first

and second bristle carriers undergo a particular combination of motions. The motions are best described in terms of the axes **X**, **Y**, and **Z**.

The **X** axis is generally referred to herein as the longitudinal axis and generally extends along a longitudinal or lengthwise dimension (as seen from the top planar view of the toothbrush) of the toothbrush head or the bristle carrier. For example, a longitudinal axis is an axis passing through the longest dimension of the toothbrush head. The **Y** axis is transverse, orthogonal or perpendicular to the **X** axis and generally bisects the toothbrush head into its left and right halves. The **Z** axis is transverse, orthogonal or perpendicular to the **X** and **Y** axes. It will be appreciated that axis orientations need not be exactly orthogonal or perpendicular to another axis and that some deviation from 90 degrees between the axes, particularly when these axes are used to describe a direction of motion. It should be understood that any axis orientation herein can be modified by the terms “generally” or “substantially” (e.g., “generally transverse” or “substantially transverse”). The word “substantially” implies some angular deviation, but not as much angular deviation from 90 degrees as the word “generally”. No modifier indicates slight to no deviation from 90 degrees. Thus, a motion that is described as occurring along a first axis transverse to a second axis implies that the motion occurs at a 90 degree angle to the second axis with some slight deviation permitted (e.g., from manufacturing tolerances, etc.). If the motion is generally transverse or substantially transverse, a greater deviation from 90 degrees is contemplated. All the axes described herein can intersect another axis either generally or substantially transverse to said other axis.

Plane **X** contains the **X** axis and is generally referred to herein as the plane of the toothbrush or the plane of the toothbrush head. This plane generally extends along the longitudinal dimension of the toothbrush. The **Y** plane contains the **Y** axis and extends through the toothbrush and is perpendicular to the **X** plane. The **Y** plane either bisects the toothbrush or is parallel to a plane that does. The **Z** plane is perpendicular to both the **X** plane and the **Y** plane and contains the **Z** axis.

Furthermore, it is useful to address the terminology used in describing the preferred embodiment toothbrushes, bristle carriers, and the various drive mechanisms. As used herein, the term “forward” refers to the direction from the handle to the head while the term “rearward” refers to the direction from the head to the handle. A longitudinal direction is a direction that generally corresponds to a longitudinal or **X** axis but which may not lie in the same plane as the axis. For example, the longitudinal axes of a shaft and a bristle carrier may not extend in the same plane but generally extend in the same direction from a top planar view. Similarly, a neck and head that are angled with respect to each other may not have longitudinal axes that extend in the same plane, but do have axes that extend in the same general longitudinal

direction from a top planar view. Many of the preferred embodiment electric toothbrushes typically have an elongated head with a longitudinal axis passing through the longest dimension thereof. This axis typically extends in the same general direction as the longitudinal axes of the toothbrush neck and/or shaft. This axis is generally referred to as the longitudinal axis of the toothbrush. By the phrase “same general direction,” some angular deviation is contemplated between the axes.

Generally, the preferred embodiment toothbrushes according to the present invention comprise an elongated hollow body containing an electrically powered motor and drive mechanism that is used to drive one, two, three or more moveable bristle carriers. The elongated hollow body also includes an interior chamber or cavity for containing one or more batteries for powering the motor. And, one or more switches are provided along the outer region of the body for activating the motor and drive mechanism. As will be appreciated, a removable end cap is provided to enclose the interior chamber and provide a seal against external agents for the components inside the toothbrush body. As described in detail herein, the preferred embodiment toothbrushes comprise one, two, three or more movable bristle carriers. Each of the bristle carriers undergoes particular types of motion and the resulting combinations of movements provide unique cleaning efficacy.

Furthermore, it is useful to define the terms “fixed” or “static” bristles, and the term “movable” bristles. The terms fixed or static bristles refer to bristles that are secured or affixed to the brush head or body of the toothbrush or other component thereof so that the bristles, and specifically, the base of the bristles, do not move with regard to the longitudinal axis of the toothbrush. Restated, fixed or static bristles refer to bristles that are affixed to the toothbrush such that their base or point of attachment does not move with respect to the toothbrush. It is recognized that the tips or regions distal from the base of a bristle or group of bristles may move as a result of flexing of the bristle. However, the base of a stationary, static, or fixed bristle does not move with respect to the brush. The term movable bristle refers to a bristle in which the base of the bristle moves with respect to the toothbrush, and particularly with respect to the longitudinal axis of the brush. Generally, this configuration is accomplished by affixing or supporting the base of the bristle to a mounting component, i.e. a bristle carrier or holder, that is movable with respect to the brush. Restated, a movable bristle is a bristle that is movable with respect to the longitudinal axis of the brush.

Fig. 2 is a partial perspective view of a preferred embodiment toothbrush **100** in accordance with the present invention. The preferred embodiment toothbrush **100** includes a body **130**, a brush head **150**, and a neck **140** extending between the body and the head. The toothbrush **100** further includes a bristle carrier assembly that features a plurality of bristle

carriers as follows. This preferred assembly includes a first bristle carrier **160**, a second bristle carrier **170**, and a third bristle carrier **180**. The first bristle carrier **160** includes a base **162**. The second bristle carrier **170** includes a base **172**. And, the third bristle carrier **180** includes a base **182**. Preferably, the first, second, and third bristle carriers, i.e. **160**, **170**, and **180** are pivotable (when incorporated in a toothbrush head) about an axis extending through one or more pivot members such as pivot members **183** and **163**. Each of the bases **162**, **172**, and **182** contain a camming member **161**, **171**, and **181**, each of which is received within a camming slot **136** defined within a cam member **134**. Each of the camming members **161**, **171**, and **181** preferably extends downward from a respective base, as shown in Fig. 2. The cam member **134** is retained within the interior of the toothbrush head and is engaged with a drive shaft **116**. As can be seen, the drive shaft **116** preferably undergoes a reciprocating-type motion. Upon reciprocal movement of the drive shaft **116**; reciprocal movement, however transverse to the movement of the drive shaft **116**, or periodic curvilinear movement is imparted to each of the bristle carriers **160**, **170**, and **180**. The specific type of motion imparted to each of the bristle carriers depends upon the configuration and engagement between the camming members and the camming slot.

Fig. 3 is a perspective view of another preferred embodiment toothbrush **200** in accordance with the present invention. The preferred embodiment toothbrush **200** includes a body **230**, a brush head **250**, and a neck **240** extending between the body and the head. The toothbrush **200** further includes a bristle carrier assembly that features a plurality of bristle carriers as follows. Fig. 3 illustrates the assembly as comprising a first bristle carrier **260**, a second bristle carrier **270**, and a third bristle carrier **280**. The first bristle carrier **260** includes a base **262**. The second bristle carrier **270** includes a base **272**. The third bristle carrier **280** includes a base **282**. Preferably, each of the bases, i.e., **262**, **272**, and **282**, provide a collar which defines an engagement slot or aperture. For example, as shown in Fig. 3, the third bristle carrier **280** includes a collar **284** that defines an engagement slot or aperture **286**. Each of the slots or apertures of a respective collar is received along a cam region **218** of a drive shaft **216**. Preferably, the drive shaft **216** undergoes reciprocating motion such that lateral motion or other motion is imparted to each of the bristle carriers **260**, **270**, and **280**. As previously explained with regard to Fig. 2, one or more of the bristle carriers **260**, **270**, **280** may include a pivot member such as member **283** in Fig. 3. Depending upon their configuration and engagement with a retaining component of a toothbrush head within which the bristle carrier assembly is incorporated, the pivot members generally serve to cause the bristle carriers to undergo a pivotal motion about the axis of the pivot members.

Fig. 4 is a perspective view of another preferred embodiment toothbrush **300** in accordance with the present invention. This preferred embodiment toothbrush **300** comprises a

body **330**, a head **350**, and a neck **340** extending between the body **330** and the head **350**. Disposed on the brush head **350** are a plurality of movable bristle carriers which in Fig. **4** as shown, include a first bristle carrier **360** and a second bristle carrier **370**. Each of the bristle carriers **360** and **370** undergo a reciprocating motion as shown upon activation of the brush. Specifically, linear reciprocating motion of a drive shaft **316**, such as from a drive mechanism (not shown) disposed in the body **330** is imparted to a second drive shaft **318** via linkage **317**. Movement of drive shaft **318** is further transmitted to a hinged component **319** and to a linking arm **320** extending between the hinged component **319** and one or both of the bristle carriers **360** and **370**.

In a most preferred aspect, a rocking arm **321** is utilized that extends between the first and second bristle carriers **360** and **370**. Most preferably, the rocking arm **321** is hinged about its center to a stationary member within the interior of the brush head **350** such that the arm **321** may move or pivot about that member. An end of the linking arm **320** is engaged to an end of the rocking arm **321** such that reciprocation of the linking arm **320** causes pivoting of the arm **321** about its center. As shown in Fig. **4**, since each bristle carrier **360** and **370** is engaged to an opposite end of the rocking arm **321**, pivoting of the arm **321** causes reciprocation of the carriers **360** and **370**. The reciprocation of each carrier **360** and **370** is out of phase with the other. Thus, when the carrier **360** moves in a forward direction, the carrier **370** moves in a rearward direction, and vice versa.

Figs. **5**, **6**, and **7** illustrate yet another preferred embodiment toothbrush **400** in accordance with the present invention. The preferred embodiment toothbrush **400** includes a body **430**, a head **450**, and a neck **440** extending between the body **430** and the brush head **450**. Disposed on the brush head **450** are a plurality of movable bristle carriers such as a first bristle carrier **460** and a second bristle carrier **470**. A drive shaft **416** extends within the neck **440** and the body **430** and imparts motion to one or both of the bristle carriers **460** and **470** from a drive mechanism (not shown). Preferably, upon operation of the toothbrush **400**, the drive shaft **416** reciprocates as shown in Fig. **5**. The distal end of the drive shaft **416** is engaged with a base **472** of the second bristle carrier **470**. As will be appreciated, the first bristle carrier **460** may be directly powered from the drive shaft **416** or indirectly powered, such as via the second bristle carrier **470**.

The preferred embodiment toothbrush **400** of Figs. **5**, **6**, and **7** features a massaging plate **480** movably disposed along a rear face of the brush head **450**. Upon operation of the toothbrush **400**, the massaging plate **480** is reciprocated generally along the longitudinal axis of the toothbrush **400**. The massaging plate is preferably formed from an elastomeric material, or other relatively soft pliable material. The outer surface of the massaging plate **480**

may be formed so as to provide one or more outwardly extending ridges, protrusions, or other members that serve to provide specific massaging characteristics. Fig. 6 illustrates various alternative versions of the massaging plate 480. A plate 480a may be provided that has a plurality of raised protrusions or other projections extending from its outer surface. A plate 480b may be used that features a plurality of outwardly extending ridges. And, a plate 480c may be used that features a relatively smooth outer surface, free of any raised or outwardly extending projections.

Fig. 7 is a partial sectional elevational view of the brush head 450 of the toothbrush depicted in Fig. 5 taken along line VII-VII. Fig. 7 illustrates a linking component 418 that engages the distal end of the drive shaft 416 to the bristle carrier 470 and to the massaging plate 480. Upon reciprocating motion of the drive shaft 416, both the bristle carrier 470 and the massaging plate 480 are moved in similar fashion.

Figs. 8, 9, and 10 illustrate yet another preferred embodiment toothbrush 500 in accordance with the present invention. The toothbrush 500 includes a body 530, a brush head 550, and a neck 540 extending between the body 530 and the brush head 550. A first bristle carrier 560 is disposed on the brush head 550. And, a second bristle carrier 570 is disposed on the brush head 550. A drive shaft 516 extends within the neck 540 and upon activation of the brush, imparts motion to one or both of the bristle carriers 560 and 570.

The toothbrush 500 provides a massaging plate 580 similar to the toothbrush 400 previously described. However, the massaging plate 580 of the toothbrush 500 does not reciprocate as does the massaging plate 480 of the toothbrush 400. This is described in greater detail herein. The massaging plate 580 is preferably formed from an elastomeric or other suitable material. The plate 580 is preferably disposed along a rearward face of the toothbrush head 550 and secured thereto. The plate 580 may be provided with a variety of different surface configurations. Fig. 9 depicts a massaging plate 580a having a plurality of outwardly extending raised regions; plate 580b having a plurality of raised ridges; and plate 580c having a smooth outer surface.

Fig. 10 is a partial sectional elevational view of the brush head 550 of the toothbrush 500 taken along line X-X in Fig. 8. A linking component 518 is provided that engages the distal end of the drive shaft 516 to the bristle carrier 570. The linking component 518 is provided with an outwardly extending bulb or region that contacts the underside of the massaging plate 580. As will be appreciated, since the plate 580 is formed from a material that is flexible and pliable, motion is imparted to the outer surface of the plate 580 as the linking component 518 is displaced along the underside of the plate 580. This configuration results in the outer surface of the massaging plate 580 exhibiting a pulsing motion and essentially vibrate upon operation of the toothbrush 500.

It will be appreciated that in all of the embodiments of the present invention, one or more groups of static bristles or other cleaning members may be provided in conjunction with the moving bristles. It may, in many instances, be preferred to provide a collection of static bristles on the toothbrush head. For example, static bristles may be disposed in a gap between bristle carriers or may completely encircle the bristle carriers. Static bristles may also be disposed at the distal-most end of the head and/or at the rearward-most portion of the head and/or adjacent the sides of the toothbrush head. Further examples of static bristles that may be used with the present invention are described in US patent application No. 10/274,40 and US patent No. 6,360,395. Moving or static elastomeric bristles, formed for example from a thermoplastic elastomer or rubber, can also be provided on the moving bristle carriers or the toothbrush head. An example of one arrangement is described in US patent No. 6,371,294.

While brush head embodiments of the present invention have been illustrated for simplicity with tufts of bristles that extend in a direction substantially perpendicular to the longitudinal axis of the head from which they extend, it is contemplated that the static and/or movable bristles might be arranged differently to compliment or further enhance the static bristles or the motion of the movable bristles. Some or all of the bristles might extend in a direction that forms an acute angle with a top surface of a bristle holder and may extend in a forward or rearward direction. In another embodiment, some of the bristles might extend outwardly away from the head, in another direction, again forming an acute angle with respect to the top surface of the bristle holder. Examples of other suitable bristle arrangements are described in US Patent Nos. Des. 330,286, Des. 434,563; 6,006,394; 4,081,876; 5,046,213; 5,335,389; 5,392,483; 5,446,940; 4,894,880; and International Publication No. WO99/23910.

The toothbrushes of the present invention may be formed from a wide array of polymers. In the following description of the preferred polymer materials for use herein, the abbreviations that are commonly used by those of skill in the art to refer to certain polymers appear in parentheses following the full names of the polymers. The polymer is preferably polypropylene ("PP"), or may be selected from the group consisting of other commercially available materials, such as polystyrene ("PS"), polyethylene ("PE"), acrylonitrile-styrene copolymer ("SAN"), and cellulose acetate propionate ("CAP"). These materials may be blended with one or more additional polymers including a thermoplastic elastomer ("TPE"), a thermoplastic olefin ("TPO"), a soft thermoplastic polyolefin (e.g., polybutylene), or may be selected from other elastomeric materials, such as ethylene-vinylacetate copolymer ("EVA"), and ethylene propylene rubber ("EPR"). Examples of suitable thermoplastic elastomers herein include styrene-ethylene-butadiene-styrene ("SEBS"), styrene-butadiene-styrene ("SBS"), and styrene-isoprene-styrene ("SIS"). Examples of suitable thermoplastic olefins herein include

polybutylene ("PB"), and polyethylene ("PE"). Techniques known to those of skill in the art, such as injection molding, can be used to manufacture the toothbrush of the present invention.

5 The present invention has been described with reference to particular preferred embodiments. Modifications and alterations may be made to these embodiments within the scope of the present invention. For example, certain combinations of bristle carriers have been described herein. It will be appreciated that the bristle carriers can be rearranged and the bristle carrier of one embodiment substituted for that of another. Further, while some bristle carriers may have a slot that engages a pin on the toothbrush head to guide the movement of the bristle carrier, it will be appreciated that these features can be reversed so that the pin is disposed on the
10 bristle carrier and the slot is disposed on the head, and further that other structures known in the art can be used to guide the motion of any of the bristle carriers described herein. It is intended that all such modifications and alterations are included insofar as they come within the scope of the appended claims or equivalents thereof.

All documents cited in the Detailed Description of the Invention are, in relevant
15 part, incorporated herein by reference; the citation of any document is not to be construed as an admission that it is prior art with respect to the present invention.

While particular embodiments of the present invention have been illustrated and described, it would be obvious to those skilled in the art that various other changes and modifications can be made without departing from the spirit and scope of the invention. It is
20 therefore intended to cover in the appended claims all such changes and modifications that are within the scope of this invention.